How Green is too Green? Public Opinion of What Constitutes Undesirable Algae Levels in Streams

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ABSTRACT

A public opinion survey was carried out in Montana to ascertain if the public identifies a level of benthic (bottom-attached) river & stream algae that is undesirable for recreation. The survey had two parts; an On-River survey and a By-Mail survey. The On-River survey was conducted via 44 trips randomly scheduled throughout the state during which recreators were interviewed in-person at the stream. Selection of stream segments and survey dates/times was based on known, statewide recreational use patterns. By-Mail survey forms were sent to 2,000 individuals randomly selected from Montana's Centralized Voter File (CVF) available from the Montana Secretary of State. The CVF was current through 2004 and represented over 85% of the state's eligible voting population. In both surveys 8 randomly-ordered photographs depicting varying levels of stream benthic algae were presented, and participants were asked if the algae level shown was desirable or undesirable for recreation. Survey form design, selection of photographs, and pre-testing followed acceptable protocols that limited unintentional bias through survey execution. There were 433 returned forms (389 complete) for the By-Mail survey, while the On-River survey documented 563 interviews. In both surveys, as benthic algal chlorophyll *a* (Chl *a*) levels increased, desirability for recreation decreased. (Other measures of benthic algae biomass are presented as well.) For the public majority, mean benthic Chl *a* levels $\geq$ 200 mg/m^2 were determined to be undesirable for recreation, whereas mean levels $\leq$ 150 mg Chl *a* /m^2 were found to be desirable. Error rates were within the survey's statistical design criteria ($\leq$ 5%). The largest potential error source was non-response in the By-Mail survey; however, the population represented by non-respondents would have to exhibit profoundly

different perceptions of river & stream algae to meaningfully alter the results. Results support earlier work in the literature suggesting 150 mg Chl *a* /m^2 represents a benthic algae nuisance threshold.

KEY TERMS: rivers/stream, algae, environmental regulations, environmental impacts, public participation

INTRODUCTION

One of the most basic components of water quality protection in the United States and abroad is the establishment of waterbody beneficial uses, which are also referred to as instream values. For example, the United States Clean Water Act (1972) requires that waterbodies be classified for the type of beneficial water uses they are to support — e.g. fisheries, aquatic life, recreation & aesthetics, and drinking. Language of a similar nature is provided in New Zealand's 1991 Resource Management Act. Within the more detail-oriented text of the administrative rules, regulations, and guidance documents that support these laws are found water-quality criteria. Water-quality criteria are numeric or narrative expressions that, if met, assure protection of the beneficial water uses. The 1972 Clean Water Act is overseen by the Environmental Protection Agency (USEPA), and many water-quality criteria are provided in USEPA's so-called blue, red and gold books (USEPA, 1973; USEPA, 1976; USEPA, 1986). These three documents indicate that the protection of recreation & aesthetics in U.S. waters requires the prohibition of undesirable or nuisance aquatic life, e.g. algae blooms. Similarly, New Zealand's guidance on interpreting the 1991 Resource Management Act (Biggs, 2000) addresses nuisance proliferations of periphtyon (i.e., stream bottom-attached algae) and recommends appropriate criteria to protect stream aesthetic, recreational, and landscape values.

In Australia, guidelines for fresh and marine water quality indicate that nuisance organisms (including filamentous algal mats) should not be present in excessive amounts (Australian Department of the Environment and Water Resources, website, http://eied.deh.gov.au/water/quality/nwqms/pubs/wqg-ch5.pdf, accessed October 29, 2007). In Montana, where the work to be presented took place, regulations that support the Montana Water Quality Act prohibit human caused conditions that result in undesirable aquatic life (Administrative Rules of Montana 17.30.637(1)(e), website, http://www.deq.state.mt.us/dir/Legal/Chapters/CH30-06.pdf, accessed October 29, 2007).

What exactly constitutes an undesirable or nuisance level of aquatic life in a waterbody can be a subjective matter, especially when it comes to protecting beneficial water uses such as recreation & aesthetics. Nevertheless, work has been published in the scientific literature describing levels of benthic (i.e., bottom attached) algae in rivers & streams that may constitute a nuisance (Horner et al., 1983, Welch et al., 1988). These two papers suggest that benthic algae levels in excess of 100-150 mg chlorophyll *a* (Chl *a*)/m^2 are a nuisance. Horner et al. (1983) reviews 26 citations describing benthic algae growth in natural and artificial streams and finds that benthic algae levels greater than 150 mg Chl *a*/m^2 are only reported in cases where nutrient enrichment was above "ordinary natural levels" (page 131). Following up on this work, Welch et al. (1988) indicate that biomass greater than 100-150 mg Chl *a*/m^2 corresponds to streambed algae coverage >20%, which they suggest may present an aesthetic nuisance. Although algae of 100-150 mg Chl *a*/m^2 may impact recreation & aesthetics, impacts by such algae levels on aquatic life is unclear (Nordin, 1985; Welch et al., 1988; Quinn and Hickey, 1990).

Horner et al. (1983) and Welch et al. (1988) — and the 100-150 mg Chl *a*/m^2 level they suggest to prevent nuisance growth — have been widely cited in the scientific literature and in government documents (e.g., Welch et al., 1989; New Zealand Ministry for the Environment, 1992; Watson and Gestring, 1996; Dodds et al., 1997; Biggs, 2000; Dodds and Welch, 2000; USEPA, 2000; Sosiak, 2002; Dodds, 2006; Carey et al., 2007; Suplee et al., 2007; Wang et al., 2007). But Horner et al. (1983) recognized that establishing a nuisance algae level required further field verification, and government documents suggesting the use of the 100-150 mg Chl a/m^2 range qualify the recommendations by noting that what constitutes too much algae to the general public has not been firmly established, or that these levels will probably protect an aesthetic beneficial use (Biggs, 2000; USEPA, 2000). Thus, some type of assessment of the public's opinion on the matter is clearly warranted.

In our study, photographs of benthic stream algae at different levels were used to assess public opinion of what might constitute a nuisance. Independent studies show a high degree of consistency between perceptual judgment of photographs of environmental scenes and perceptual judgment of the same scenes experienced directly (Zube, 1974; Shuttleworth, 1980; Kellomäki and Savolainen, 1984; Stewart et al., 1984; Stamps, 1990). Photographs preclude the need to transport large numbers of study participants to the environmental sites in question (Shuttleworth, 1980; Daniel and Meitner, 2001), and can be used to show conditions that may not currently exist (Manning and Freidmund, 2004). The latter point was particularly relevant to our study, as some benthic algae (e.g., the filamentous algae *Cladophora* sp.) can demonstrate peak levels that develop rapidly in early summer and then again in early fall (Whitton, 1970), the timing of which is highly variable. It would have been very difficult to coordinate the study with such time-variable events.

The use of photographs to represent environmental scenes has the advantages outlined above, but is not without shortcomings. Photographs cannot invoke dynamic elements like sound, motion, or other factors which can be significant components especially in environments involving streams & rivers (Hetherington et al., 1993; House, 1996). In general, the validity of using a particular presentation medium (like photographs) depends on how well that medium can convey the key components of an environmental scene to the participants who are judging specific aspects of the scene (Hetherington et al., 1993; Manning and Freimund, 2004). We concluded that photographs would convey the "key components" needed for study participants to judge what were (or were not) undesirable algae levels, as previous work consistently discuss/present nuisance algae in contexts that can readily be assessed by eye. For example, large benthic algal growths interfere with swimmers and boats (physical entanglement of both), are unpopular with fisherman because of the danger of slipping and the snagging of lines, and are very conspicuous (unaesthetic) from the bank (e.g., Whitton, 1970; Horner et al., 1983, Biggs and Price, 1987; Welch et al., 1988; Biggs, 2000). All these factors can be assessed visually in a quality photograph. Furthermore, the New Zealand Ministry for the Environment uses photographs of varying benthic algae levels to convey to the public the appearance of different algae quantifications (Chl a/m^2, % bottom cover, etc.) (New Zealand Ministry for the Environment, 1992; Biggs, 2000).

Herein we present results from a survey that assessed the public's opinion concerning river & stream benthic algae levels. The objective was to determine if the general public identifies a particular level of benthic algae that is not desirable for recreation. In summer 2006 the Montana Department of Environmental Quality (MT DEQ) and the University of Montana surveyed the public on their perceptions of benthic algae in rivers & streams as it affected water recreational activities, whatever those activities might be. To our knowledge, this is the only large-scale research that has explored the relationship between public perceptions of benthic algae levels in rivers & streams and recreation water uses. Study surveys were carried out on two groups that were not mutually exclusive: river & stream users throughout Montana, and registered Montana voters. We found that the public majority showed a clear preference for benthic algae levels at or below 150 mg Chl *a*/m². These findings provide strong support for the more qualitatively derived recommendations of Horner et al. (1983) and Welch et al. (1988).

METHODS

Overview of Survey Goals and Design

The survey was carried out in Montana (Figure 1) on two public groups that were not mutually exclusive. An On-River survey was carried out on wadeable rivers & streams throughout the state, and a By-Mail survey was sent to randomly-selected registered Montana voters. The first was undertaken because the opinion of active river & stream users was considered particularly relevant. This group included Montana residents and visitors. The second group (registered Montana voters) was chosen because the outcome of the survey had the potential to impact Montana water quality regulations, and therefore the opinion of a representative sample of Montanans was important. We also tracked in the On-River survey the opinions of residents *vs*. non-residents to elucidate if actively recreating Montanans had opinions different from visitors. In both surveys we tracked opinions by region and by watershed, as the location where a public opinion survey is carried out can significantly influence the results (Ross and Taylor, 1998; Brunson and Shindler, 2004), and we wanted to be able to test for this.

Both surveys consisted of the same randomly-ordered photographs of Montana rivers & streams, each photograph depicting a different algae level. In the On-River survey, the survey's purpose and instructions were verbally provided to participants in-person by an interviewer; for the By-Mail survey, these were provided on the survey form. In each survey, participants were asked to indicate if the algae level in each photograph was desirable or undesirable in relation to their main form of river & stream recreation. We did not specify which recreation, thus allowing survey participants to respond relative to whatever form of river & stream recreation they enjoyed. The terms desirable and undesirable (as apposed to alternatives like acceptable/unacceptable) were chosen because they have long been used in U.S. national water quality criteria (e.g., "Surface waters should be free of substances attributable to discharges or wastes [which] … produce undesirable aquatic life") (Federal Water Pollution Control Administration, 1968; USEPA, 1973; USEPA, 1976; USEPA, 1986), and we believed they would be easily understood for making a choice. Error rates for responses to each photograph were targeted to be ≤ 5%. Further details about each survey are provided later in Methods.

Selection of Photographs for the Survey

Photographs representing a range of algae levels found in Montana rivers & streams were selected from the collection of one of the authors. At each photographed site, 10 to 20 benthic algae samples had been collected and analyzed so that the benthic algal Chl *a* (extracted with EtOH and corrected for phaeophytins) (Sartory and Grobbelaar, 1984) and ash free dry weight (AFDW) (Clerceri et al., 1998) of the stream cross-section seen in each photograph was known. Many different sites had been sampled over a number of years, providing a large collection of photographs. The mean of the repeat measures of algae at each site during any given sampling event provided a benthic Chl *a* density (mg /m^2) and AFDW (g/m^2) for each photograph. Photographs of river & stream sites were available that showed a range of mean benthic Chl *a* from < 50 mg/m^2 to 1,276 mg/m^2. This generally covers the maximum range of benthic algae measured in MT rivers & streams. Photographs included streams in which bottom algae was filamentous, diatomaceous or, often, a combination of both.

Photographs were sorted by visual clarity and consistent perspective, and then grouped into benthic Chl *a* "bins" (ca. 50 mg Chl a/m^2 bin, ca. 100 mg Chl a/m^2 bin, ca. 150 mg Chl a/m^2 bin, etc.). Algae bins were staggered by about 50 mg Chl a /m^2 as it is the authors' experience that a visual distinction can best be made between algae levels staggered at this degree of resolution. A "zero" level was not provided because levels below 50 mg Chl a /m^2 are, in our experience, difficult to visually discern from 50 mg Chl a /m^2. Each algae bin was initially represented by between 5-20 photographs. The photographs were then provided to a review committee (MT DEQ Water Quality Standards Section; six individuals, one an author on the present study). Each member was asked to identify a photograph for each bin that best represented the central tendency of the series of photographs in the bin — that is, it was not too "green", and not too "clean". (The author who is a member of the Standards Section did not reveal his choices to the team prior to their selections.)

The survey was developed using 8 of the committee-selected photographs. Each was assigned a letter, and are ordered here by reach mean Chl *a* values (lowest to highest): (A) 44 mg/m^2, (G) 112 mg/m^2, (F) 152 mg/m^2, (E) 202 mg/m^2, (B) 235 mg/m^2, (H) 299 mg/m^2, (C) 404 mg/m^2, and (D) 1,276 mg/m^2 (Appendix A). Other algae characterizations (g AFDW/m^2, dominant algae type, % filamentous cover) are shown in Table 1. In general, stream bottom coverage by filamentous algae is higher at higher Chl *a* levels (Welch et al., 1988), and this is reflected in our photograph set. The photographs with the second-highest and highest Chl *a* values (C and D) do not follow the approximate 50 mg Chl a/m^2-increment pattern. This was done because (1) practical matters of design and simplicity kept the survey to 8 photographs, (2) we wanted to have the most resolution among photographs in the mid-range algae levels, as that was where a nuisance threshold (per Welch et al., 1988) was most likely to be identified, and (3) we wanted to show the public the full range of algae levels common in Montana. Variation around the reach-mean Chl *a* value for each of the 8 photographs (standard error of the mean as a percent of the mean) ranged from 5% to 27% (mean 14%). Given this variation and for simplicity, for the remainder of this article each photograph's reach mean Chl *a* level is presented rounded to the nearest 10 mg/m^2.

Pre-Test of the Survey Form & Testing of Photograph Sequence

Survey form design and refinement followed generally accepted public opinion survey techniques (Dillman, 2000). A pre-test of a draft By-Mail survey form was undertaken on 44 individuals in Helena, MT. The pre-test survey form closely resembled the final form in that it had an introduction and instructions, a dichotomous choice for each photograph, and presented the 8 photographs in the same randomly-derived order. The 44 individuals asked to take the survey were not randomly selected, but most were not directly involved with this water quality issue and so provided information on the survey form's clarity and logic. Two changes to the final survey form resulted from the pre-test results. One photograph (D; 1,280 mg Chl *a* $/m^2$) was replaced with a photograph from the same site but looking downstream (rather than upstream) which also depicted 1,280 mg Chl *a* $/m^2$. This was done because color hues of the original photograph were thought to be too bright relative to the other 7 photographs and confused decision making. The other change was the addition of, in the survey form's introduction, a statement that if a stream's algae level was naturally high MT DEQ would take no action (Appendix A). This stemmed from individuals' comments that they were concerned that their answers would lead MT DEQ to chemically treat and kill algae in streams that have naturally elevated algae levels, an action they did not want to occur.

To evaluate potential bias resulting from the presentation order of the survey photographs, in summer 2006, 32 recreators along the Clark Fork River in Missoula, MT were asked for their opinion (desirable, undesirable) concerning the algae level shown in each of the 8 photographs as it would affect their recreation. The 8 photograph were shown on laminated 20.3 cm x 25.4 cm sheets and were presented in a particular random order. Later in the summer a second, randomly-selected presentation order of the same 8 photographs was prepared and 31 recreators along the same Clark Fork River reach were similarly interviewed. These data were not included in the By-Mail or On-River survey analyses.

By-Mail Survey

By-mail surveys were sent to individuals randomly selected from Montana's Centralized Voter File (CVF) available from the Secretary of State. This file was current through 2004, contained about 624,000 records, and represented over 85% of the eligible voting population of Montana. The CVF list provided unbiased selection of sampling units because people on the CVF list are certified and there is minimal over- or under-representation of individuals, making it a good sample frame. Simple random sampling procedures were used to select individuals from the CVF. Sample size was determined using very conservative levels (99% confidence level, ± 3% sampling error, 50/50 split, very large population > 500,000)(Dillman, 2000). This calculates to 1,837 surveys; we mailed out 2,000 surveys as it was within our budget and helped assure we would ultimately achieve our goal of a 5% sampling error rate.

The cover of the By-Mail Survey (Appendix A) explained the purpose of the survey and provided instructions on how to fill it out. Inside the pamphlet, the 8 photographs were presented in a random order. Next to each photograph, the respondent was asked to mark the box indicating if the algae level was desirable or undesirable relative to their major form of river & stream recreation. Respondents were also provided a few lines with each photograph to explain their answer, if they chose to. A return envelope with a postage stamp was included with each survey.

Survey implementation was intended to maximize response. We used as a guide generally accepted techniques from Dillman's (2000) Tailored Design Method (TDM), but departed from the TDM in some ways. Dillman (2000) calls for a 5-contact approach, the last 3 of which are follow-ups after the survey is mailed ([3] a reminder/thank you postcard, [4] a replacement survey for non-respondents, and [5] telephone/certified mail contact for non-respondents). In our study complete anonymity of respondents was deemed critical given the potential regulatory implications of the work and, in addition, anonymity may increase response rate (Kindra et al., 1985) and accuracy (Kerin and Peterson, 1977). This decision precluded strict adherence to the last two TDM steps. In our study, each potential respondent was first sent a single-page letter introducing the project and notifying them that they would be receiving a survey. A week after the introductory letter, the survey forms were sent out. A week after the survey was sent, follow-up postcards were sent to everyone, encouraging recipients to complete and return their survey and thanking them if they already had. This 3-contact process occurred between July 21 and August 4, 2006.

In September 2006, about 60 days after the By-Mail survey forms were mailed out, it was clear that non-response was high (ca. 78%). Preliminary analysis showed that response splits were far different from 50/50 for each photograph and, as a result, the response rate was already adequate to meet the study's design criteria. But we wanted to try and characterize non-respondent opinions due to concerns about potential bias, so results from respondents were then used to estimate the number of follow-ups needed. These were calculated by specifying particular confidence levels around the response to a photograph under different scenarios (e.g., number follow-ups required to maintain 95% confidence level in the response to a photograph when non-respondents respond X% differently than the original respondents). The calculations provided a range of follow-ups from 50-400. In September 2006, 150 randomly selected individuals from the CVF list were contacted by phone and asked if they would fill out and return the survey. Because the study was anonymous, this process included individuals that had already responded.

Selection of River & Stream Segments for the On-River Survey

On-River surveys were conducted via 44 survey trips randomly scheduled throughout the state. Angling is a dominant activity at fishing access sites throughout Montana (Montana Fish, Wildlife and Parks, website, http://fwp.mt.gov/content/getItem.aspx?id=11065, accessed April 2005), and therefore provided a good indication of relative river & stream recreation use. Selection of stream segments and survey dates for the survey was based on angling-use patterns summarized by the Montana Department of Fish, Wildlife, and Parks (FWP) (McFarland and Tarum, 2005; an updated, web-available version of the report is at http://fwp.mt.gov/content/getItem.aspx?id=29639). Prior to using FWP's list a few large, non-wadable river segments (as judged by the authors) were removed, as our main interest was the opinion of recreators using stream reaches similar to those in the photographs. FWP's list provided the On-River survey's sampling frame and directly informed unbiased selection of sample units (recreational use by time and location) through a two-stage random sampling scheme. Primary sample units were represented by FWP river drainages; probability of selection was proportional to angler use on wadeable streams. Within each primary sampling unit, secondary sample units were represented by streams that had been shown to have fishing pressure according to the FWP survey; probability of selection was proportional to angler use within the drainage. The randomly scheduled order in which stream reaches were to be surveyed was further scheduled (randomly) for interviews to occur either in the morning from 06:00-11:00, or in the afternoon & evening, 13:00-18:00 (Table 2).

Surveys were undertaken from June 17 to August 27, 2006. At the beginning of the survey (June 17 to June 20), a field interviewer noted that encounters with recreators would likely be more effective if the evening interview period was moved later in the day. The authors concurred and, from June 25 until the end of the survey, p.m. interviews were carried out from 14:00-19:00. Interview site and time scheduling was strictly adhered to, with only a small number of minor changes (e.g., two stream reaches within a primary sampling unit [drainage] to be sampled sequentially were done in the reverse order from originally planned). Interviewer scheduling conflicts required that the ultimate surveys (Aug 28/29) be completed a week earlier (Aug 24/25).

On-River Survey Interview Process

River & stream segments on which survey interviews were carried out varied widely, but were often about 80 km long. Most river & stream segments had roads along them, with designated and undesignated public access points. Some segments, however, were only accessible by foot trails or by intermittent Forest Service roads crossing the water. The survey protocol reflects the diversity of accessibility to the segments.

The interviewer approached each survey segment from the headwaters and moved downstream. On a few occasions where travel time was underestimated, interviewing was begun before reaching the headwaters. The interviewer stopped at each designated or undesignated public fishing access point and interviewed any recreators present at that location. After finishing any available interviews, the interviewer proceeded to the next public access downstream. If the interviewer completed surveying along the length of the survey segment before the five hour survey allocation, she turned around and repeated the process heading upstream.

In the case of a foot trail on a closed loop (no access from other trails/roads), the interviewer positioned herself at the trailhead in order to interview stream users both coming and going. If the river or stream was located along an open loop foot trail (access to other trails/roads), and there were vehicles present at the trailhead, the interviewer walked as much of the length of the stream as possible, given time and personal safety considerations.

Upon approaching a potential respondent, the interviewer identified herself as from the University of Montana, working on a project with MT DEQ. She explained to the respondent that the goal of the project was to determine if and when algae in rivers & streams was ever a nuisance to recreators. Respondents were asked to examine the 8 photographs provided (same photographs and order used in the By-Mail survey), and express whether they found the level of algae shown in each to be desirable or undesirable for their primary river or stream recreational activity, and why. At the end of the interview, the interviewer recorded for each respondent whether they were a Montana resident. She also gave each respondent the opportunity to ask any questions about the project. Most interviews lasted from two to three minutes, but up to twenty minutes in rare cases. Longer interviews resulted when respondents had extensive questions about the project or wanted to share their particular algae experiences. Any river user encountered who was capable of comprehending what the survey asked was encouraged to take the survey. This included some youths and several visitors from foreign countries.

Inferential Statistics

After the On-River surveys were complete and the By-Mail returns had stopped, six comparisons were evaluated using statistical test methods appropriate to binomially distributed data. These were (1) comparison of responses to a standard level of 50%; (2) comparisons of responses among photographs within each survey; (3) comparisons of responses within each survey to Chl *a* levels; (4) comparisons of responses among survey locations, (5) comparisons of responses by residency; and (6) comparisons of responses between surveys (i.e., By-Mail *vs*. On-River). Where applicable, reach-mean Chl *a* values were used in tests. Specifics are provided below.

(1) The proportion of desirable responses for each photograph was compared to a standard value of 50%. Fifty percent was selected because it represents a simple majority, which is a logical and clearly understood threshold. For binomial data, it also represents a level the difference from which represents a meaningful response; i.e., different from a coin flip. For each comparison, a two-sided null hypothesis was stated that the proportion observed was equal to 50%; the alternative hypothesis was that the proportion observed was not equal to 50%. The binomial sign test for a single sample was employed (Sheskin, 1997) using a calculated z-

statistic, appropriate for large samples, to approximate the test-statistic. All tests used an *a priori* 5% significance level.

(2) Within each survey, the McNemar test (Sheskin, 1997) was used to evaluate the likelihood that preferences differed among photographs presented. This test was conducted for all pairs of photographs, testing the null hypothesis that there was no difference in respondents' preferences between two photograph pairs. All tests were two-sided (*a priori* 5% significance level).

(3) Within each survey, the test of significance for Kendall's tau (Sheskin, 1997) was used to evaluate the relationship (correlation) between percent desirable response by photograph and the Chl *a* levels depicted. This was evaluated for each survey testing the null hypothesis that no correlation existed.

(4) Within each survey, comparisons were conducted to evaluate whether preferences varied significantly by survey location. The z test for two independent proportions was employed (Sheskin, 1997) testing the null hypothesis that there was no difference in percent desirable responses between survey results from two locations. In the case of the By-Mail survey, respondent identities were unknown, however the main post office of origin of each returned survey had been recorded. Therefore, for By-Mail surveys, comparisons were conducted among locations defined by the post office of origin. For the On-River surveys, comparisons were conducted among responses by the drainage where the survey was conducted. All tests were two-sided (*a priori* 5% significance level).

(5) Within each survey, comparisons were conducted to evaluate whether preferences varied significantly by residency. The z test for two independent proportions was employed (Sheskin, 1997) testing the null hypothesis that there was no difference in percent desirable

responses due to residency (MT resident *vs.* non-resident). All tests were two-sided (*a priori* 5% significance level).

(6) Comparisons were conducted to evaluate whether preference for a particular photograph varied significantly (*a priori* 5% significance level) between surveys. The z test for two independent proportions was employed (Sheskin, 1997), testing the null hypothesis that there was no difference in percent desirable responses to a given photograph between surveys.

RESULTS

For each photograph, the percent of desirable responses was not significantly different between the two different randomly-ordered photograph presentations. Both photograph orders yielded the same relative rank of photographs based on percent desirable responses (Table 3). Therefore, the effect of photograph order was not considered significant or meaningful and was not further considered in interpreting the results.

For the By-Mail survey there were 433 returned surveys, 389 of which were complete (all answers filled out) and could be used in statistical analyses. The 150 telephone follow-ups were unsuccessful, in that only 14 individuals indicated they would fill out a provided survey and, at most, 7 of these were returned. For the On-River survey, there were 563 documented interviews. Recreators of all kinds were encountered during these interviews, including wading fisherman, rafters, canoeist, kayakers, swimmers, tubers, and sight-seers. Results from each survey are summarized in Tables 4 and 5, indicating for each photograph the number of respondents who considered the Chl *a* level depicted to be desirable or undesirable, the percentage of respondents who considered the level to be desirable, and the 95% confidence level of this proportion expressed as percent error. All error rates are within the statistical design criteria for the survey (i.e., less than 5%). Results from the On-River and By-Mail surveys depict similar patterns of response to the Chl *a* levels represented. For both groups of survey respondents, as algal chlorophyll levels increased the desirability for recreation decreased. Specifically, levels of Chl $a \geq 200$ mg/m^2, represented by photographs E, B, H, C and D (Appendix A) were determined to be undesirable for recreation by both groups of survey respondents. Levels ≤ 150 mg Chl *a* /m^2, represented by photographs A, G and F, were determined to be desirable. Results for each of the six statistical analyses described in Methods are given below.

(1) Comparisons to a Standard Level

In all instances — all photograph results in both surveys — the proportion of desirable responses was significantly different than 50% ($p<0.05$). Therefore, all responses can be considered meaningful in that they show significant preferences (desirable or undesirable) for each photograph.

(2) Comparisons Among Photographs Within a Survey

Within each survey, significant differences were found between most pairs of photographs within both surveys. Exceptions occurred at the lower extreme of Chl *a* levels — A (40 mg/m^2) *vs.* G (110 mg/m^2) from the By-Mail survey — and among selected photographs considered undesirable by the public majority — E (200 mg/m^2) *vs.* C (400 mg/m^2) and H (300 mg/m^2) *vs.* D (1,280 mg/m^2) from the By-Mail survey and E (200 mg/m^2) *vs.* B (240 mg/m^2) from the On-River survey. Therefore, responses can be considered meaningful in that they show preferences that differ significantly among the photographs presented.

(3) Comparisons of Responses to Algae Chl a Levels

In both surveys, the null hypothesis was rejected in favor of the one-sided alternative hypothesis that a negative correlation existed ($p<0.05$). That is, as the Chl *a* levels depicted increased, the percent of desirable responses was shown to significantly decrease. Therefore, responses can be considered meaningful in that preferences show concordance with algae levels depicted in the photographs.

(4) Comparisons Among Survey Locations

Table 6 summarizes By-Mail survey results showing percent desirable responses by post office of origin; twenty-one (21) responses had an unidentifiable post mark and are not included in this summary. Table 7 summarizes On-River survey results showing percent desirable responses by drainage basin. Values in each table are shaded if the preference is significantly different than 50% (i.e., meaningful). In several instances — Billings, Butte, Missoula, and Kalispell postmarks and Big Hole, Bitterroot, and Upper Flathead drainages — results for all photographs were significantly different than 50% ($p<0.05$). Otherwise, among the remaining locations, one or more results for photographs F through H — the midrange of algae levels depicted — exhibited preferences that were not significant. Small sample size is a factor in many of these negative results; however, several locations — Great Falls postmark and Beaverhead, Upper Clark Fork, and Upper Missouri drainages — had larger sample sizes and still exhibited no significant preference for one or more of these photographs.

Where photograph preferences were meaningful (i.e., significantly different from 50%) in Tables 6 and 7, the difference in percent desirable response between locations was evaluated. For the By-Mail survey, the null hypothesis was accepted in most cases; i.e., photograph preference did not vary significantly between respondents with different postmarks. Two notable exceptions were respondents' preference for photograph B (240 mg Chl *a*/m^2) in Billings *vs*. Missoula, and preference for photograph F (150 mg Chl *a*/m^2) in Wolf Point *vs*. Missoula. Conversely, for the On-River survey, many significant differences were evident between drainages. Such differences occurred for each photograph and results from every drainage differed with one or more other drainages.

In no instance, in either survey, is there a significant difference where a photograph preference from one location was desirable (>50%) and the preference from another location indicated the same photograph was undesirable (<50%) — or vice versa. Rather, significant differences indicated differences in the degree of acceptability — or unacceptability — between locations. For instance, 34.3% of Billings respondents considered photograph B (240 mg Chl *a*/m^2) to be desirable compared to 17.9% of Missoula respondents; this difference is significant, but the majority of both Missoula and Billings respondents consider the algae level depicted to be undesirable. Therefore, whereas comparisons indicate some variation in photograph preferences among locations — more so in the On-River survey than the By-Mail survey — results were consistent at the level of 50% (simple majority).

(5) Comparisons by Residency

Table 8 summarizes photograph preference for 382 Montana residents surveyed and 181 non-residents encountered. All preferences are meaningful in that they are significantly different from 50% ($p<0.05$). Within each group, most preferences were significantly different between photograph pairs; exceptions exist at the extremes, i.e. photograph A (40 mg Chl *a*/m^2) *vs*. G (110 mg Chl *a*/m^2) and C (400 mg Chl *a*/m^2) *vs*. D (1,280 mg Chl *a*/m^2), and also for photographs E (200 mg Chl a/m^2) *vs.* B (240 mg Chl a/m^2). Results from each group are concordant with associated Chl *a* levels. Finally, in no instance is there a significant difference in photograph preference between Montana residents and non-residents. Therefore, results for each group are meaningful and, between each other, show comparable preferences for the photographs presented.

(6) Comparisons between Surveys

Figure 2 shows the percent desirable responses for each photograph as observed in each survey. Photographs are ordered in progression of Chl *a* levels depicted. Both surveys exhibit a similar pattern of response; however, there are notable differences. For most individual photographs — A, F, E, H, and C — percent desirable response differed significantly between the two surveys. Surveys only agree on the level of preference for photographs G, B, and D. Also, there appears to be confusion in the By-Mail survey between photograph E (200 mg Chl a/m^2) *vs.* B (240 mg Chl a/m^2) and photograph H (300 mg Chl a/m^2) *vs.* C (400 mg Chl a/m^2). Whereas both surveys are concordant with Chl *a* levels depicted, the By-Mail survey does not depict a perfect relationship. Nevertheless, there is clear threshold in both surveys between those photographs considered desirable (>50%) and those considered undesirable (<50%) — a level of interpretation relevant to a simple majority. Significant differences among preference levels noted above are only indications of differences in degree of acceptability — or unacceptability. Therefore, from the perspective of a simple majority, results between surveys can be considered comparable and supportive of one another.

DISCUSSION

Sample frames provided for coverage of most Montanans and most recreational users of wadeable rivers & streams in the state. Sampling design yielded results that met statistical design criteria for precision of results. Furthermore, sample size tended to provide sufficient power for detecting differences between photographs, between groups, and between surveys. Survey form design, selection of photographs, and pre-testing followed acceptable protocols that limit unintentional bias through survey execution (Dillman, 2000). Independent evaluation of photograph order indicated that unintentional bias was not introduced. Overall, the largest potential source of survey error is acknowledged to be attributable to non-response in the By-Mail survey. Efforts to characterize non-respondent perceptions were unsuccessful, and a discussion of potential effects follows.

We carried out an anonymous survey, believing that it was appropriate for a regulatory government agency, would result in more accurate answers (Kerin and Peterson, 1977) and, therefore, reduce measurement error. But anonymity precluded strict adherence to the 5-contact TDM (Dillman, 2000), consequently reducing the number and changing the manner of our multiple contacts. Multiple contacts are one of the most effective ways to reduce non-response error (Dillman, 1991), although anonymity can also reduce non-response error (Kindra et al., 1985). Response rates were comparable in eastern (ca. 20%) and western (ca. 18%) Montana (each distinct geographic regions of the state; more on this below), indicating that a regional bias in non-response was not introduced. Overall, one can only speculate as to how non-response was affected by a reduced number of contacts (likely decreased response rate) *vs.* assured participant anonymity (likely increased response rate).

In general, the population represented by non-respondents would have to exhibit a profoundly different perception of algae in wadeable rivers & streams in order to alter the proportions depicted in the Results at a meaningful level. Perceptions of algae by non-respondents would have to be opposite those exhibited in the By-Mail and On-River surveys in order to meaningfully alter the trends observed in Figure 2. We assert that this is unlikely to occur and the fact that two different surveys — By-Mail and On-River — provide comparable results supports this assertion. A more likely outcome from the inclusion of non-respondent perceptions would be either to shift preferences up or down (due to more or less tolerance to algae), or moderate overall preferences (due to overall indifference to algae). In either case, the proportions would still likely be significantly different than 50% (i.e., show a preference), but they would be less likely to be significant among photographs (i.e., not be distinct preferences). Overall, the same general grouping of desirable and undesirable photographs depicted in Figure 2 would likely go unchanged.

In the Introduction we outlined some water quality regulations in the U.S. and abroad intended to protect against nuisance algal blooms and proliferations. Eutrophication of rivers & streams is a phenomenon that often leads to nuisance algae conditions. Eutrophication is the enrichment of a waterbody by nitrogen and phosphorus that frequently leads to increased primary productivity, i.e. increased plant growth and decay (e.g., Welch et al., 1989; Welch, 1992; Chessman et al., 1992; Sosiak, 2002; Dodds, 2006). So, how does the algae level found to be desirable for recreation identified in the present study ($\leq$ 150 mg Chl a/m^2) compare to algae levels found in streams having varying degrees of eutrophication? Biggs (1996) reports that a group of un-enriched streams in New Zealand have a typical range of 0.5-3 mg Chl a/m^2 (median = 1.7 mg Chl a/m^2), whereas moderately enriched streams normally range from 3-60 mg Chl a/m^2 (median = 21 mg Chl a/m^2), and enriched streams are usually in the range of 25-260 mg

Chl a/m^2 (median = 84 mg Chl a/m^2). The acceptability threshold from the present study falls within the enriched category of these streams. In Montana, Suplee et al. (2005) define a process for identifying reference streams and list 129 such sites around the state. Reference stream sites are, by definition, minimally impacted by human activities (Hughes et al., 1986; Stoddard et al., 2006) and therefore should not be very enriched relative to natural conditions. In western Montana, a region dominated by the Rocky Mountains where most streams have gravel substrates, good gradient, and support trout fisheries, 26 reference streams had a range of mean benthic algal Chl *a* levels from 3-75 mg Chl a/m^2 (median = 14 mg Chl a/m^2). In contrast, in northeastern Montana, which is part of the Northern Great Plains (Hunt, 1974) and is dominated by warm-water fish species (e.g., walleye) and low-gradient prairie streams, 8 reference streams had a range of mean benthic algal Chl *a* levels from 2-302 mg Chl a/m^2 (median = 24 mg Chl a/m^2), with 97% of the sampled reaches falling below 150 mg Chl a/m^2. So in Montana, it appears that the algae level at the recreation nuisance threshold (150 mg Chl a/m^2) is much higher than what is found in mountainous reference streams, and is only rarely found in prairie reference streams.

Dodds et al. (1998) present a classification scheme for rivers & streams modeled after the classic one for lakes (oligotrophic, or low productivity; mesotrophic, midrange productivity; and eutrophic, productive) (Wetzel, 1975). The Dodds classification was derived from a benthic algae cumulative frequency distribution for 200 streams from North America and New Zealand of varying degrees of eutrophication, and places the breaks for the 3 classes at the lower, middle, and upper thirds of the dataset. Interestingly, the boundary between mesotrophic and eutrophic streams was given as 200 mg Chl a/m^2 (maximum) (Dodds et al. 1998) and matches the first benthic algae level in our study considered undesirable (200 mg Chl a/m^2). Further, the cumulative frequency distribution of an enlarged version of the Dodds et al. (1998) dataset shows that, across a set of worldwide temperate rivers & streams of varying degrees of eutrophication, there is an inflection point around 150 mg Chl a/m^2 (mean); algae levels above this value are generally uncommon (Dodds et al., 2002). Thus, benthic algae levels characterized in the literature as uncommon and representing the onset of eutrophic conditions in temperate streams worldwide correspond with what the public perceived to be, in our study, the onset of excessive algal growth.

As in our study, environmental perception studies involving streams and public waters have often focused on visual characteristics that may affect public acceptability. Studies show that river and lake water color & clarity clearly influence suitability for swimming, water clarity in particular showing a distinct threshold beyond which most feel the water is unsuitable (Smith and Davies-Colley, 1992; Smith et al., 1995a, b). Public enjoyment of rivers and beaches is diminished more by solid waste contaminants (e.g., toilet paper, bottles, cans) in the water than up on the banks (House, 1996), and varying levels of solid litter at water sites (artificially placed for a study) diminish recreational values and lead participants to incorrectly assume the water itself is polluted (Dinius, 1981). Regarding the present work, participants in the On-River survey were clear about what they did not like about some of the photographs. This is illustrated by the fact that 78% had a comment about how their recreation would be interfered with by the algae levels they deemed undesirable. Some listed several reasons, but for simplicity we tally here only their first-mentioned reason. 33% stated fishing was affected (e.g., snags lures, etc.), 23% indicated wading impacts (e.g., slippery, dangerous, would wrap around legs), 11% cited swimming interference (e.g., looks unsuitable, would get entangled), 11% stated strictly aesthetic reasons, 2% stated boating interference (e.g., entangles paddles), and 20% had comments not readily classifiable into the aforementioned groups.

The public majority showed a high degree of consistency in our study regarding what constitutes desirable and undesirable algae levels, regardless of their location in the state. For example, the majority of citizens from Billings (i.e., eastern prairie region of Montana) found benthic algae levels greater than 150 mg Chl *a*/m^2 to be unacceptable, as did people in mountainous western Montana (i.e., Butte, Missoula, and Kalispell). But the geography and nature of rivers & streams of these two regions is very different, and benthic algae levels from reference streams of each region have different ranges. Due to these geographic differences we had expected significant regional differences in majority public opinion, however this was not the case; only the degree to which specific algae levels were desirable or undesirable changed. Similarly, both resident and non-resident respondents identified the same maximum threshold for a desirable algae level (150 mg Chl *a*/m^2). These results suggest that our findings can be applied beyond Montana to small rivers and streams in northern and southern temperate regions that are of a similar nature to those shown in Appendix A.

In conclusion, statistical analysis of responses establishes that meaningful preferences were evident for the photographs presented. Proportions of "desirable" responses (i.e., those indicating that an algae level was acceptable for recreational use of a river or stream) indicated either significant satisfaction or dissatisfaction with the levels of Chl *a* depicted; except in isolated cases, preferences between photographs were significant; and, levels of preference exhibited concordance with the algae levels (i.e., more algae, less desirable). Furthermore, results showed that the acceptability of the algae levels depicted in each photograph were consistent among locations and between residents and non-residents; acceptability was also consistent between the two surveys. It can be meaningfully concluded that, among Montanans and recreational users of Montana rivers & streams, benthic algae levels less than or equal to 150 mg Chl *a*/m^2 represent desirable levels for recreation while 200 mg Chl *a*/m^2 and higher levels are undesirable for recreational activities.

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Table 1. Quantification of Algae Levels, Dominant Algae Type, and Reach Description from Field Notes on the Day of Sampling.

Photograph Letter	Mean Benthic Algae Level (mg Chl *a* /m^2)	Mean Benthic Algae Level (g AFDW/m^2)	Dominant Algae Type	Reach Description (Field Notes)
A	44	10	Diatoms	Almost bare to naked eye, no filaments
G	112	30	Diatoms	5-10% of rocks had *Cladophora* ; the remaining rocks were bare or lightly coated with diatoms
F	152	36	Diatoms	50-80% *Cladophora* cover, but filaments only 1 cm long; the filaments were very diatom encrusted as were the rocks
E	202	95	Filamentous	20-60% *Cladophora* cover; 3-30 cm long filaments
B	235	117	Filamentous	50% *Cladophora* cover, very diatom-encrusted
H	299	209	Filamentous	30-100% *Cladophora* cover; 50-100 cm long filaments
C	404	136	Filamentous	70% *Cladophora* cover, 10-30 cm long filaments
D	1,276	221	Filamentous	90% *Cladophora* cover; 30-50 cm long filaments

TABLE 2. Pre-Arranged, Randomly-Derived Visitation Schedule for Stream Reaches in the On-River Survey.

Month	Drainage Trip	Drainage Name	Stream Trip	AM/PM	Stream Reach
June	June 17/18	Big Hole Drainage	Sat	PM	Big Hole River Sec 02
			Sun	AM	Big Hole River Sec 02
	June 19/20	Upper Clark Fork Drainage	Mon	PM	Rock Creek Sec 01
			Tues	AM	Little Blackfoot R Sec 02
	June 24/25	Bitterroot Drainage	Sat	PM	Bitterroot River Sec 02
			Sun	AM	Boulder Creek
	June 26/27	Madison Drainage	Mon	PM	Madison River Sec 02
			Tues	AM	Madison River Sec 02
July	July 1/2	Upper Yellowstone Drainage	Sat	PM	Sage Creek
			Sun	AM	Stillwater River Sec 02
	July 1/2	Upper Clark Fork Drainage	Sat	PM	Warm Springs Creek
			Sun	PM	Clark Fork River Sec 03
	July 3/4	Beaverhead Drainage	Mon	PM	Bloody Dick Creek
			Tues	AM	Poindexter Slough
	July 8/9	Upper Clark Fork Drainage	Sat	PM	Flint Creek Sec 01
			Sun	AM	Storm Lake Creek
	July 10/11	Big Hole Drainage	Mon	AM	Big Hole River Sec 03
			Tues	AM	Big Hole River Sec 02
	July 15/16	Bitterroot Drainage	Sat	PM	Lolo Creek
			Sun	AM	Bitterroot River Sec 02
	July 17/18	Beaverhead Drainage	Mon	PM	Beaverhead River
			Tues	PM	Beaverhead River
	July 24/25	Blackfoot Drainage	Mon	AM	Blackfoot River Sec 02
			Tues	AM	Blackfoot River Sec 02
	July 29/30	Upper Clark Fork Drainage	Sat	AM	Storm Lake Creek
			Sun	AM	Clark Fork River Sec 03
	July 31/Aug 1	Mussellshell Drainage	Mon	PM	Checkerboard Creek
			Tues	PM	Spring Creek
August	Aug 5/6	Upper Flathead Drainage	Sat	AM	M Fk Flathead River
			Sun	PM	M Fk Flathead River
	Aug 12/13	Bitterroot Drainage	Sat	PM	Lost Horse Creek
			Sun	PM	Bitterroot River Sec 02
	Aug 14/15	Upper Yellowstone Drainage	Mon	PM	Rock Creek Sec 01
			Tues	PM	Rock Creek Sec 01
	Aug 19/20	Upper Missouri Drainage	Sat	PM	Missouri River Sec 09
			Sun	AM	Missouri River Sec 09
	Aug 21/22	Upper Missouri Drainage	Mon	AM	Missouri River Sec 09
			Tues	PM	Missouri River Sec 09
	Aug 21/22	Upper Clark Fork Drainage	Mon	AM	Rock Creek Sec 02
			Tues	PM	Warm Springs Creek
	Aug 26/27	Upper Yellowstone Drainage	Sat	PM	Rock Creek Sec 01
			Sun	PM	Rock Creek Sec 01
	Aug 28/29	Upper Yellowstone Drainage	Mon	PM	Bighorn River Sec 01
			Tues	AM	Stillwater River Sec 01

Table 3. Summary of Random Photograph Order Surveys.

Photograph	Chlorophyll a (mg/m^2)	Random Order #1 (n=32)		Random Order #2 (n=31)	
		Presentation Order	Percent Desirable	Presentation Order	Percent Desirable
A	40	1	100%	1	97%
G	110	7	97%	3	94%
F	150	6	78%	8	77%
E	200	5	63%	7	48%
B	240	2	41%	5	35%
H	300	8	22%	2	16%
C	400	3	9%	4	10%
D	1,280	4	19%	6	13%

Table 4. Summary of the By-Mail Survey, Montana Residents (n = 389).

Photograph	Chlorophyll a (mg/m^2)	Number Desirable	Number Undesirable	Percent Desirable	Percent Error
A	40	372	17	95.6%	2.0%
G	110	369	20	94.9%	2.2%
F	150	271	118	69.7%	4.6%
E	200	64	325	16.5%	3.7%
B	240	112	277	28.8%	4.5%
H	300	49	340	12.6%	3.3%
C	400	65	324	16.7%	3.7%
D	1,280	44	345	11.3%	3.1%

Table 5. Summary of the On-River Survey, Recreational River & Stream Users (n = 563).

Photograph	Chlorophyll a (mg/m^2)	Number Desirable	Number Undesirable	Percent Desirable	Percent Error
A	40	553	10	98.2%	1.1%
G	110	527	36	93.6%	2.0%
F	150	427	136	75.8%	3.5%
E	200	179	384	31.8%	3.8%
B	240	164	399	29.1%	3.8%
H	300	114	449	20.2%	3.3%
C	400	65	498	11.5%	2.6%
D	1,280	51	512	9.1%	2.4%

Table 6. Summary of the By-Mail Survey of Montana Residents, by Post Office. Values are Shaded if Preference is Significantly Different From 50%.

Photo	Post Office of Response Origination								
	Billings n=99	Wolf Point n=7	Miles City n=13	Great Falls n=48	Havre n=14	Helena n=23	Butte n=42	Missoula n=78	Kalispell n=44
A	94.9%	100%	100%	91.7%	85.7%	95.7%	95.2%	98.7%	95.5%
G	93.9%	100%	100%	95.8%	92.9%	100%	97.6%	93.6%	90.9%
F	70.7%	100%	69.2%	72.9%	64.3%	65.2%	69.0%	61.5%	72.7%
E	20.2%	14.3%	15.4%	18.8%	7.1%	13.0%	23.8%	12.8%	9.1%
B	34.3%	71.4%	46.2%	37.5%	28.6%	21.7%	23.8%	17.9%	25.0%
H	10.1%	14.3%	23.1%	16.7%	14.3%	4.3%	21.4%	11.5%	11.4%
C	12.1%	14.3%	15.4%	20.8%	21.4%	21.7%	19.0%	14.1%	15.9%
D	7.1%	28.6%	7.7%	14.6%	7.1%	0.0%	23.8%	11.5%	11.4%

Table 7. Summary of the On-River Survey of Recreational River Users, by Drainage. Values are Shaded if Preference is Significantly Different From 50%.

Photo	FWP Drainage									
	Beaver-head n=63	Big Hole n=70	Bitter-root n=129	Black-foot n=19	Madison n=21	Mussel-shell n=15	Upper Clark Fork n=83	Upper Flathead n=67	Upper Missouri n=83	Upper Yellow-stone n=13
A	100%	97.1%	100%	100%	100%	93.3%	95.2%	98.5%	98.8%	92.3%
G	98.4%	94.3%	87.6%	100%	100%	86.7%	91.6%	92.5%	98.8%	100%
F	87.3%	82.9%	66.7%	73.7%	57.1%	86.7%	74.7%	79.1%	77.1%	76.9%
E	52.4%	30.0%	17.1%	15.8%	23.8%	33.3%	39.8%	19.4%	48.2%	30.8%
B	39.7%	31.4%	8.5%	57.9%	19.0%	33.3%	15.7%	29.9%	55.4%	53.8%
H	25.4%	12.9%	8.5%	0.0%	19.0%	46.7%	18.1%	22.4%	42.2%	15.4%
C	25.4%	5.7%	2.3%	0.0%	23.8%	6.7%	9.6%	3.0%	30.1%	7.7%
D	22.2%	5.7%	2.3%	0.0%	19.0%	0.0%	6.0%	6.0%	18.1%	15.4%

Table 8. Summary of the On-River Survey of Recreational River Users, by Residency.

Photograph	Montana Residents (n = 382)			Non-Residents (n = 181)		
	Number Desirable	Number Undesirable	Percent Desirable	Number Desirable	Number Undesirable	Percent Desirable
A	376	6	98.4%	177	4	98.2%
G	354	28	92.7%	173	8	93.6%
F	291	91	76.2%	136	45	75.8%
E	123	259	32.2%	56	125	31.8%
B	115	267	30.1%	49	132	29.1%
H	78	304	20.4%	36	145	20.2%
C	40	342	10.5%	25	156	11.5%
D	33	349	8.6%	18	163	9.1%

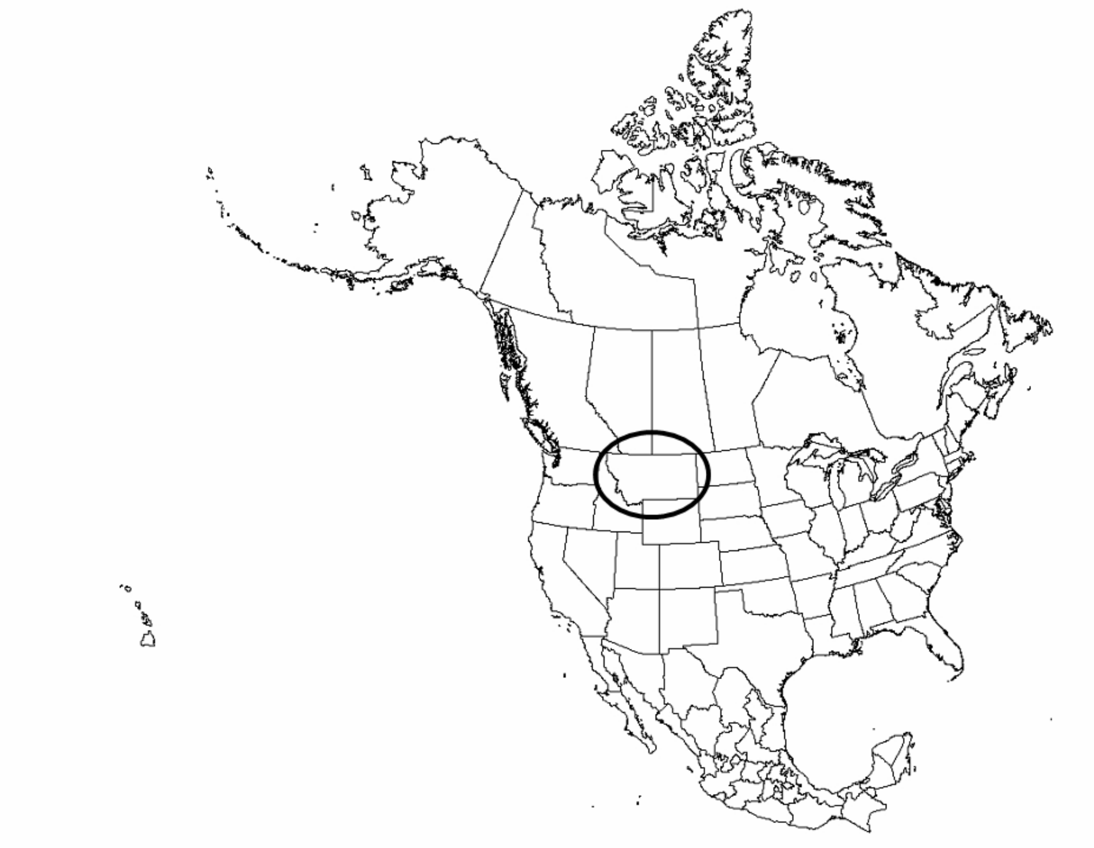


Figure 1. Map of North America Showing the State of Montana, Where the Study Took Place.

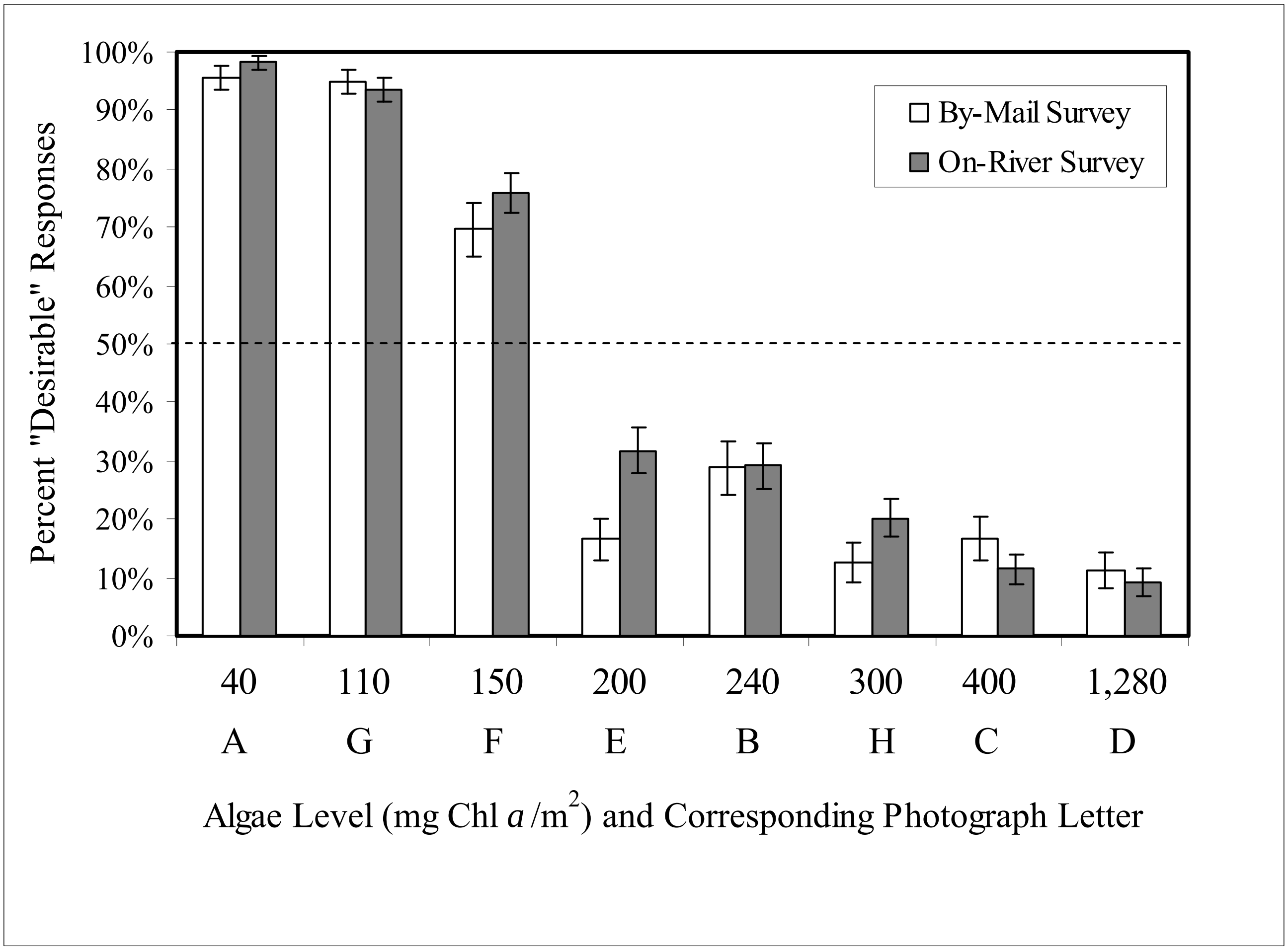


Figure 2. Percent Desirable Responses from the By-Mail and On-River Surveys. Letters designating the survey photographs are sequenced from lowest to highest algae level. Error bars are the 95% confidence level of each proportion, expressed as percent error.

APPENDIX A. The 8 Photographs Used in the Survey. The By-Mail survey form was a five page pamphlet with the text (shown below) on the front cover and the 8 photographs (two per page) inside. Adjacent to each picture were two choices (desirable/undesirable) and a space for comments. Here, the photographs are lettered and shown in the same order as they appeared in the survey. The dimensions of the pictures have been slightly modified to accommodate journal publication.

OPINION SURVEY:
ALGAE LEVELS IN MONTANA RIVERS & STREAMS

Dear Montana Citizen;

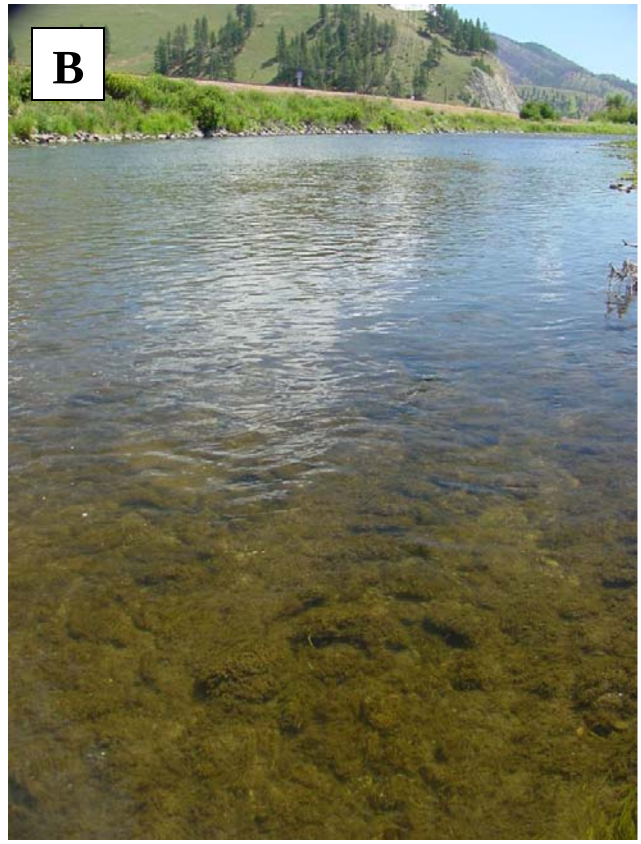
Montanans recreate in and on rivers & streams in many ways, from swimming to fishing to boating. Algae are often found in our rivers & streams, and may have the potential to affect people's recreation in different ways. The Montana Department of Environmental Quality (DEQ) would like to determine if and when river & stream algae become a nuisance to water-related recreation in Montana. The University of Montana has agreed to conduct this survey.

Inside this survey booklet are some pictures that represent different types and levels of common attached algae you might encounter in Montana rivers & streams. We would like your opinion of these pictures.

As you look over each picture, please think about whether the algae level shown would be desirable or undesirable in relation to your main recreational use of rivers & streams. Then, check the appropriate box next to each picture, and write down a few words in the space provided to tell us why. Please know that you and your responses will remain anonymous.

The DEQ will use this information to determine if and when river & stream algae become a nuisance to water-related recreation. If some levels of algae are found to be undesirable to Montana river & stream users, then the DEQ would take steps to assure that pollution sources causing those levels are properly addressed. However, we would like you to know that if a river or stream's algae levels are naturally high, the DEQ would take no action.


A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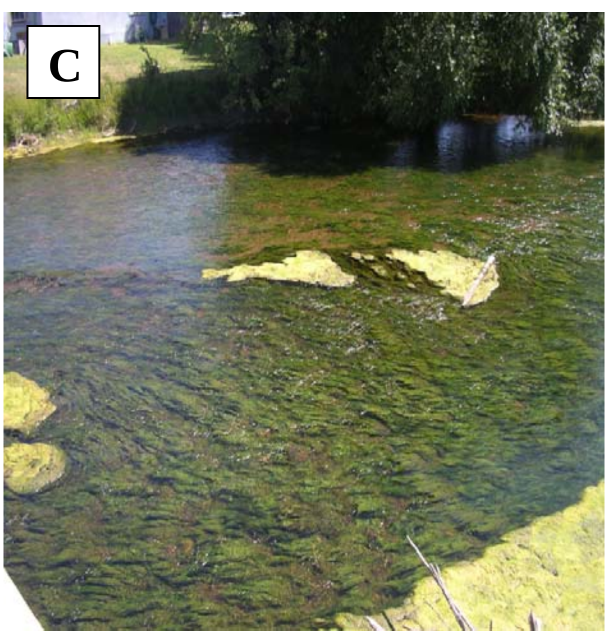
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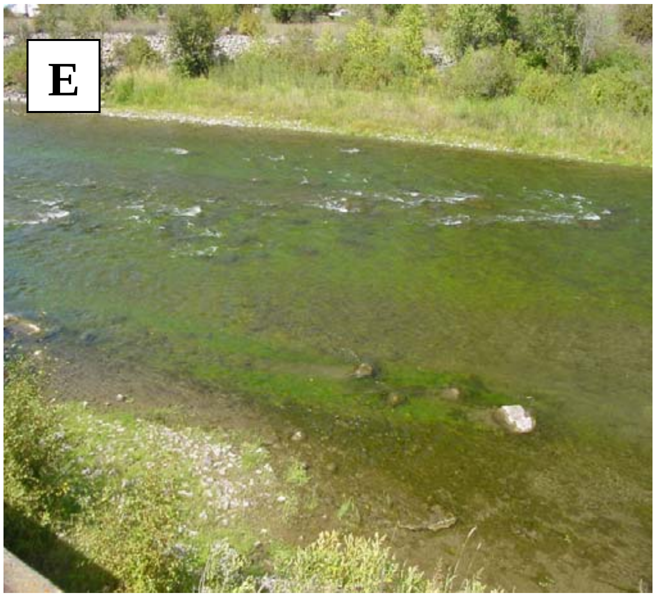
D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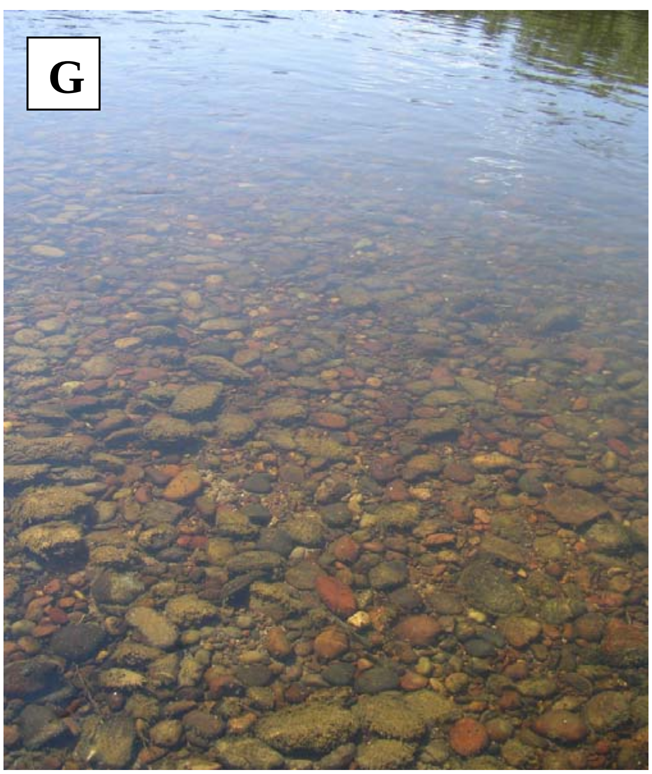
F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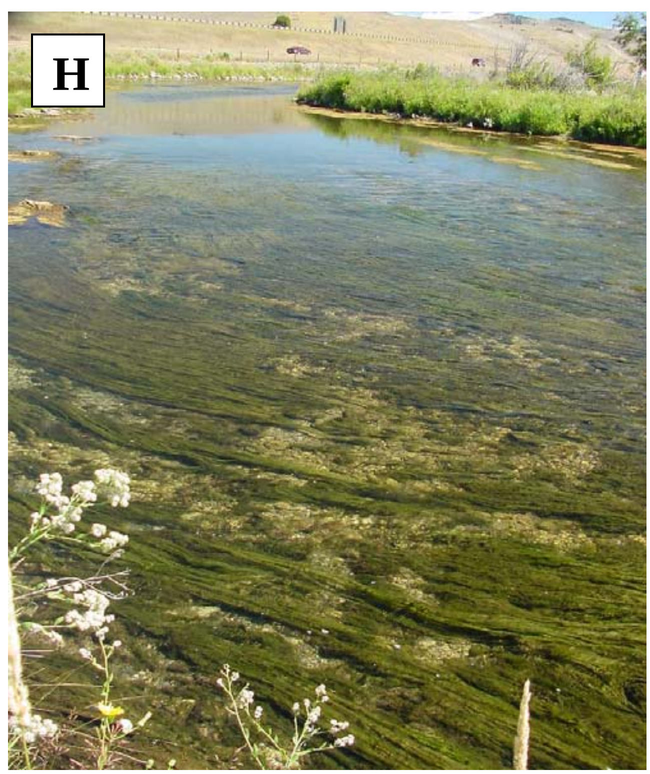
H